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USSR: The Gas Industry Through 1985

An Intelligence Assessment

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*Central Intelligence Agency
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Key Judgments

The USSR is unquestionably depending upon natural gas to help carry it past any difficulties caused in the next several years by stagnating or falling oil production. The Soviets are intensifying their efforts to exploit their extremely large gas reserves (referred to by the Soviet press as "blue gold") and have good reason to emphasize the gas industry's rapid development:

- Unlike the Soviet oil industry, the gas industry has been extremely successful in finding new reserves. Almost all of the giant hydrocarbon discoveries announced by the Soviets since the early 1970s have been gas, and proved reserves probably now equal at least 40 years of production at the 1977 level of 346 billion cubic meters (cu m) compared with only about 10 years for oil.
- Despite repeated failure to meet plan goals, the gas industry has grown more than twice as fast as the oil industry over the past two decades and now provides nearly one-fourth of Soviet fuel supplies. Between now and 1985, gas output will contribute most of the increments to total Soviet fuel production, and by 1985 it could constitute more than one-third of total Soviet fuel output. Natural gas is already a major industrial fuel in the USSR and the country's fastest growing source of export receipts.

Although the Soviet gas industry has the potential to maintain substantial production growth through the next decade, several major obstacles may hold down its rate of expansion.

- Most of the country's gas production now occurs in the European USSR and Central Asia, but these regions contain only about 30 percent of total reserves, and new discoveries have not kept pace with output over the past decade. Production from many of these regions' large fields is declining, and may be doing so at a faster pace than we estimated earlier.

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- Future growth of the gas industry depends on rapid development of the large deposits of northern West Siberia—both to offset declines in other regions' output and to allow for substantial growth. Development of this arctic area is unprecedented in the history of the world's oil and gas industries and poses problems of field development and pipeline and compressor station construction and operation not previously encountered in either the USSR or the West. Even with further imports of Western gas equipment (notably pipe and compressors), the USSR may not avoid a substantial slowing of growth in West Siberian—and thus Soviet—gas output.

Moscow appears to have grown more concerned since mid-1977 over the pace of West Siberian gas development.

- Articles in the Soviet press complaining of slow or inadequate construction of pipeline and gasfield projects have become more frequent and frank.
- Moscow has recently assigned more of the 1976-80 Five-Year Plan budget to oil and gas development in West Siberia and has hurriedly dispatched additional men and equipment to that region.
- Because vital infrastructure in northern Siberia is virtually nonexistent, however, even a major stepped-up campaign to open the region's gas deposits probably will produce through 1985 only marginally more gas than that provided without additional efforts.

Gas will help ease the impending decline in Soviet oil production. Nonetheless, it will not solve the country's emerging energy problems.

- Gas will substitute for oil in several sectors of the economy, but not rapidly or to the extent necessary to prevent potential tight energy supplies.
- Gas by 1985 will become the leading earner of hard currency in trade with the West, but it will probably not equal the receipts currently being obtained by Soviet oil exports.

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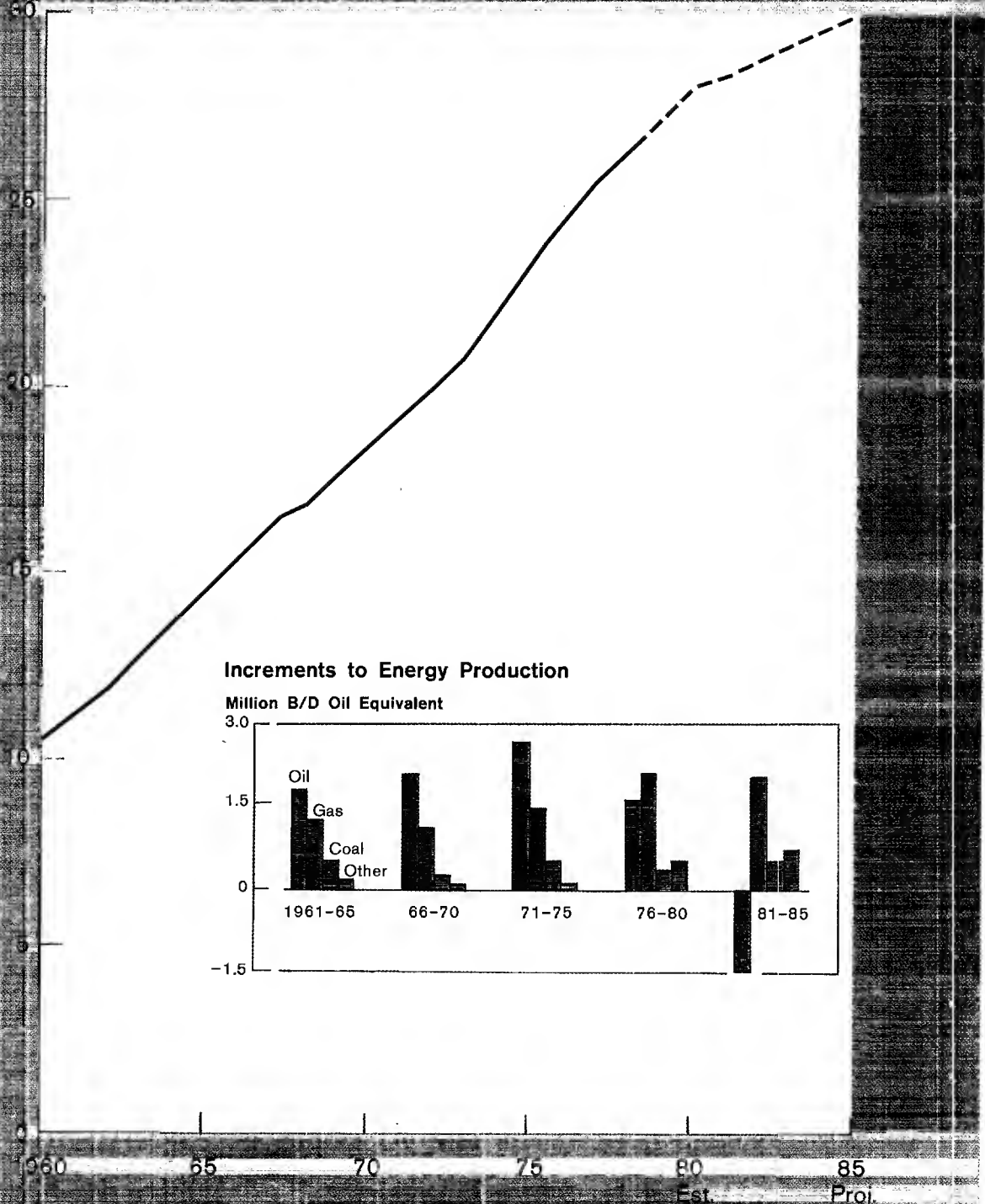
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USSR: Energy Production

Figure 1

Million B/D Oil Equivalent



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USSR: The Gas Industry Through 1985

Introduction

Soviet natural gas production until recently has drawn much less attention than Soviet production of oil, which currently constitutes 45 percent of domestic fuel output versus 24 percent for gas and 28 percent for coal. Natural gas, however, is the most dynamic sector of Soviet fuel production. Despite its repeated failure to meet plan goals, the Soviet gas industry has grown rapidly, becoming second only to that of the United States. Its impressive capacity for continued expansion suggests that its importance to both foreign and domestic consumers will eventually approach that of oil. The purpose of this paper is to provide an analysis of the problems and prospects facing the Soviet gas industry for the next few years.

bottlenecks in production will not prevent gas from increasing its importance in total Soviet energy supplies, but they could lead to occasional interruptions.

The importance of gas to the Soviet energy balance and to hard-currency trade is steadily increasing. Gas already constitutes 24 percent of Soviet fuel production, against 45 percent for oil. Its export level to the West since 1970 has risen to one-fifth of that for oil (in caloric equivalent). More important to Soviet planners, the growth potential for gas remains significant while oil production will begin its decline by the early 1980s. During 1971-75, gas added about one-half as much energy to Soviet supplies as did oil; during 1976-80, gas will probably add more than oil—2.2 million barrels per day (b/d) oil equivalent compared with about 1.7 million b/d. During 1981-85, prospective increases in gas supplies (2.1 million b/d oil equivalent) probably will more than offset declines in oil production (see figure 1).

The USSR may have up to 28 trillion cu m in proved, probable, and possible reserves, at least four times as much as equivalent US reserves.¹ West Siberia's northern Tyumen' Oblast contains several of the world's largest known gas deposits, and the trunkline system being built to link them with consumers in the European USSR and farther west is unprecedented in its length and potential throughput capacity.

Gas production in 1977 grew by 8 percent compared with 1976 production and was 4 billion

¹ It is possible that the Soviets have recently revised downward their gas reserve estimate. Although Soviet data released in 1976 and 1977 indicated that reserves of 28 trillion cu m had been reached, recent Soviet statements have failed to give a current reserve estimate and suggest that the figure may be lower, perhaps around 23 trillion cu m. This report, however, will use the estimate of 28 trillion cu m.

Gas in Perspective

Soviet natural gas production has ended a boom phase in its development and is entering an era of slower growth. This is occurring, somewhat paradoxically, as the Soviets begin exploiting their largest gasfields. The concentration of the USSR's major gas reserves in a single, remote region—West Siberia—will increasingly hamper gas extraction now that other large sources of regional growth are gone. Resulting

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cu m above planned production, reaching 346 billion cu m (33 billion cubic feet per day)—the industry's second consecutive overfulfillment of an annual plan. Output since 1970 has grown at an impressive 8.3-percent annual rate. Maintaining such growth, however, will prove to be much more difficult in the future. Growth will likely drop well below the current 8-percent average annual rate; gas output in 1980 is likely to reach about the middle of the target for 400 billion to 435 billion cu m in the 1980 plan. It is unlikely to do better than reach the bottom of the range of 560 billion to 600 billion cu m projected for 1985. Gas nevertheless will provide by far the largest increments of any major fuel in total Soviet energy production during 1976-85. By 1985 gas could account for approximately 40 percent of total fuel output. It could also replace oil as the leading commodity in Soviet exports by 1985.

The impending slowdown in gas production growth stems from two developments of the late 1970s:

- Significant growth potential is now more concentrated in a single region than at any time since the mid-1960s when the Soviet gas industry began to grow rapidly. West Siberia's northern Tyumen' Oblast (see the map) possesses most of the major untapped Soviet reserves feasibly exploitable in the next decade (see table 1). Yet the cost and physical difficulty of developing these deposits and piping the gas 3,000 to 5,000 kilometers (km) for domestic consumption and export poses unprecedented problems for Soviet energy ministries.²
- Simultaneously, combined production from the country's other gas regions will decline. This will force West Siberia to cover increasingly large losses in national output before actually making net additions to total gas supply (see figure 2). Non-West Siberian

Table 1

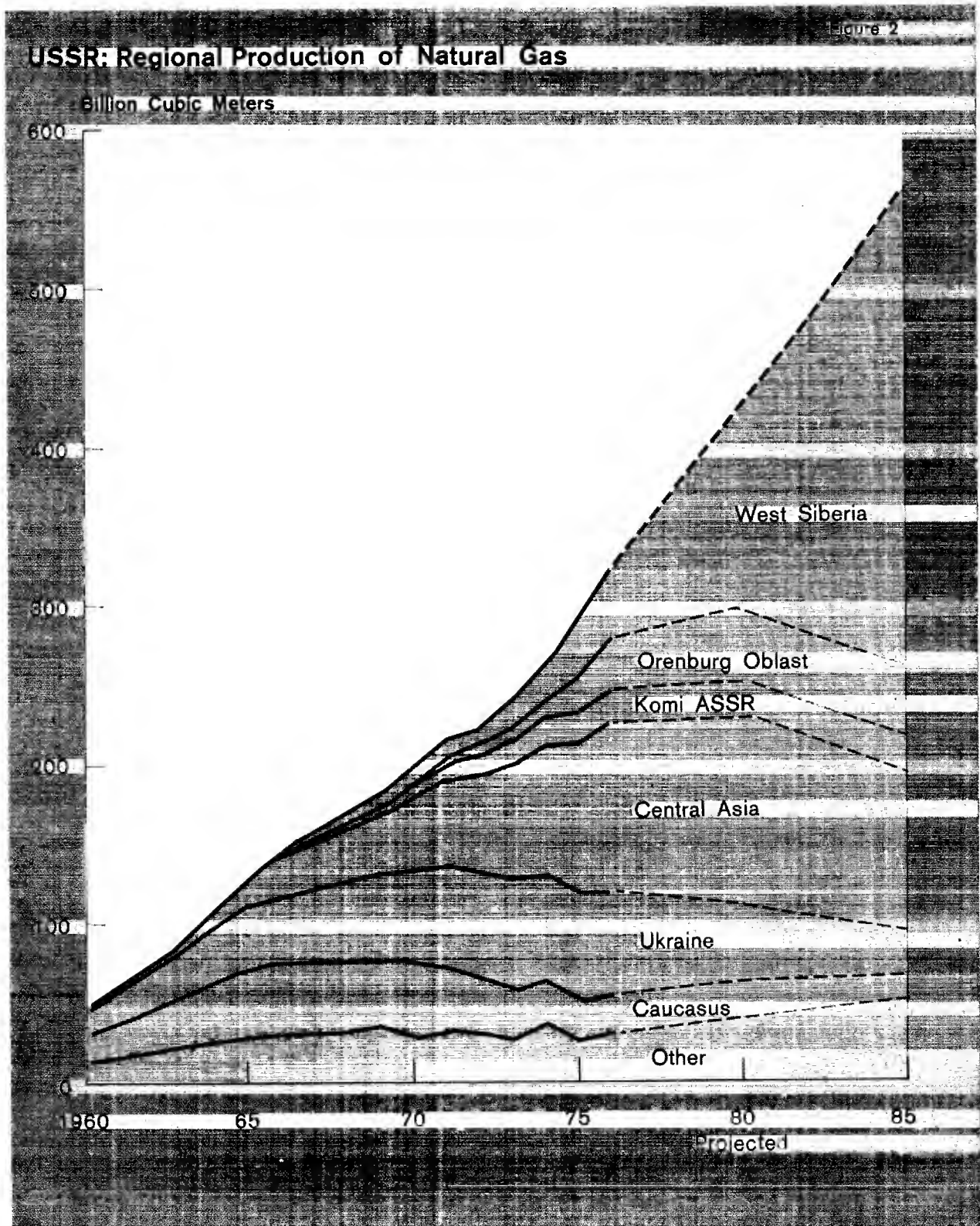
Tyumen' Oblast Gas Industry¹

| | Reserves (A + B + C ₁) ² (Billion Cubic Meters) | Percent of USSR Reserves | Production (Billion Cubic Meters) | Percent of USSR Output | Reserves/ Production Ratio |
|------------|---|-----------------------------|---|---------------------------|----------------------------------|
| 1960 | 50.2 | 2.2 | 0 | 0 | |
| 1961 | 50.2 | 2.0 | 0 | 0 | |
| 1962 | 70.1 | 2.5 | 0 | 0 | |
| 1963 | 130.1 | 4.2 | 0 | 0 | |
| 1964 | 200.3 | 6.2 | 0 | 0 | |
| 1965 | 300.3 | 8.4 | 0 | 0 | |
| 1966 | 400.8 | 11.2 | 0.6 | 0.4 | 668 |
| 1967 | 895.8 | 20.4 | 5.2 | 3.3 | 172 |
| 1968 | 4,030.6 | 42.8 | 8.2 | 4.8 | 492 |
| 1969 | 4,914.3 | 40.7 | 9.1 | 5.0 | 540 |
| 1970 | 6,834.9 | 56.5 | 9.2 | 4.6 | 743 |
| 1971 | 9,252.3 | 58.7 | 9.3 | 4.4 | 995 |
| 1972 | 10,608.7 | 58.9 | 11.4 | 5.1 | 931 |
| 1973 | 11,797.4 | 60.4 | 15.8 | 6.7 | 747 |
| 1974 | 13,749.5 | 61.3 | 21.8 | 8.4 | 631 |
| 1975 | 15,490.0 | 63.0 | 36.8 | 12.7 | 421 |
| 1976 | 17,000.0 | 61.0 | 44.0 | 13.7 | 386 |
| 1977 | NA | NA | 67.9 | 19.6 | NA |

¹ Sources: A. D. Brentz, *Ekonomika gazodobyvayushchey promyshlennosti*, p. 28; *Geologiya, bureniye i razrabotka gazovykh mestorozhdeniy*, no. 4 (1977), p. 3; *Ekonomicheskaya gazeta*, no. 24 (1978), p. 1.

² Soviet and Western oil and gas reserve concepts differ, and Soviet reserve estimates are not always reliable. Nonetheless, Soviet A reserves plus some portion of adjacent B reserves correspond to the US "proved reserves" category. The remainder of B reserves and some fraction of the C₁ reserves fall into the US "probable" classification. Most of the remainder of the C₁ reserves fall into the US "possible" category.

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gas production peaked in 1977 and will decline for the first time in 1978 (see table 2). Extraction rates are falling at major, but old, fields of the Ukraine, Uzbekistan, and the North Caucasus, and recent information indicates that the decline may be accelerating faster than we had previously expected. Certainly by the early 1980s these regions will constitute a severe drag on overall gas industry growth. Moreover, output may have peaked for Central Asia, until last year the leading source of production growth. By 1980, extraction may begin declining in the region's prolific Turkmen SSR and in the Komi ASSR, also a source of recent growth.³

Tyumen': Pluses and Minuses

The large gas deposits of northern Tyumen' present both opportunities and serious challenges to the Soviet gas industry. More than 80 percent of the region's reserves of 17 trillion to 19 trillion cu m are in eight large fields (Urengoy, Yamburg, Zapolyarny, Medvezh'ye, Kharsavei, Bovanenko, Semakov, and Neitinsk), which will facilitate deployment of industry resources toward both field development and construction of

³ For a detailed discussion of the decline in output from older producing regions, see *USSR: Development of the Gas Industry*, op. cit.

Table 2

USSR: Growth in West Siberian Gas Production

Billion Cubic Meters

| | Production | | Annual Change in Output | |
|-------------------------|--------------|-------|-------------------------|-------|
| | West Siberia | Other | West Siberia | Other |
| 1970..... | 9.2 | 188.7 | 0.1 | 16.7 |
| 1971..... | 9.3 | 203.1 | 0.1 | 14.4 |
| 1972..... | 11.4 | 210.0 | 2.1 | 6.9 |
| 1973..... | 15.8 | 220.5 | 4.4 | 10.5 |
| 1974..... | 21.8 | 238.8 | 6.0 | 18.3 |
| 1975..... | 36.8 | 252.5 | 15.0 | 13.7 |
| 1976..... | 44.0 | 276.6 | 7.2 | 24.1 |
| 1977 ¹ | 67.9 | 278.1 | 23.9 | 1.5 |
| 1978 ² | 99.0 | 271.0 | 31.1 | -7.1 |

¹ Estimated.² Plan

pipelines linking those fields. However, all of those deposits straddle the Arctic Circle and are under permafrost many tens of meters thick. Of greater concern to Soviet planners, the fields are great distances from the major industrial and urban consuming centers in the European USSR, necessitating construction of transmission pipelines thousands of kilometers long. During this five-year plan alone, the USSR plans to add 35,400 km of large-diameter gas transmission lines and great numbers of compressors, mainly to link these reserves with the consuming regions in the European USSR.⁴ Only the United States has ever added more major gas trunkline during any five-year period.

The magnitude of West Siberia's potential output and its prospective problems has been reflected in the gas industry's rapidly growing investment in the region. Development of the huge Medvezh'ye deposit in the early and mid-1970s increased the northern Tyumen' share of annual industry investment to well over 30 percent (see table 3). Medvezh'ye is now the Soviets' largest operating gasfield and the only significant northern Tyumen' deposit fully developed so far. Its jump in output from 44 billion cu m in 1976 to over 66 billion in 1977 accounted for almost all gas industry growth last year. The field's gas has been transported to the European USSR through the Nadym-Punga-Nizhny Tagil-Gor'kiy (now the Urengoy-Center) pipeline and apparently, in the past two

⁴ Together with planned additions of 18,000 km of large-diameter oil pipelines, this represents the equivalent of one Alaska pipeline every six weeks—much of it under environmental conditions even more severe than those encountered on the Prudhoe-to-Valdez route.

Table 3

Annual Capital Investment in Northern Region Gas Projects as Percent of Total Gas Industry Investment¹

| 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976-80 |
|------|------|------|------|------|------|---------|
| 6.6 | 14.8 | 25.1 | 31.8 | 33.8 | 39.2 | 80.0 |

¹ Not all projects accounted for here strictly involved Tyumen' Oblast gas. However, most investment, particularly in the later years shown, was most likely tied to that region's gas industry. Source: *Ekonomika gazovoy promyshlennosti*, no. 8 (1977), p. 36.

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years, through a linkup with the Northern Lights trunkline.

Tyumen' gas development during 1976-80 will prove much more expensive than in 1971-75. In pouring roughly 15 billion rubles—80 percent of the Ministry of the Gas Industry total—into the region in that period (equal to about 4 percent of total industry investment for that period), Moscow plans to raise West Siberian output in 1980 to 155 billion cu m.⁵ That increase would provide more than 80 percent of the gas industry's growth while raising the northern Tyumen' share of Soviet gas output to well over one-third.

The key to growth in the next few years is the Urengoy deposit, which with 5 trillion cu m of reserves (equal to total US gas reserves in the 48 conterminous states) is probably the world's largest gasfield. The Soviets apparently are planning to hike Urengoy's output rapidly from 15 billion cu m in 1978, when it will come on stream, to 58 billion to 60 billion cu m in 1980. The nearby Vyngapur deposit also is being drilled to produce almost 5 billion cu m in 1978 and up to 15 billion in 1980. Development of the Komso-mol'sk, Yubilenoy, and Gubkin fields has also begun. Facilities to process up to 16 billion cu m of associated gas from Samotlor and other oilfields in southern Tyumen' are also planned to reach full capacity in 1980.

More than 500 extraction gas wells are scheduled for drilling during 1976-80—the largest number of gas wells ever completed in any one Soviet region during a five-year plan. Included are 229 wells at Urengoy and 148 additional wells at Medvezh'ye, which is to peak at approximately 65 billion cu m this year.

Three pipeline systems will move 139-billion-cu m output in northern Tyumen' to Soviet and European consumers (see the map). Medvezh'ye and Urengoy gas will be handled by an expanded Northern Lights system running to the western Soviet border and by the Urengoy-Center system, also with expanded capacity. Construction

⁵ Northern Tyumen' Oblast would produce 139 billion cu m, while associated gas from the southern Tyumen' oil region would account for the remainder.

has begun of a third system (Urengoy-Vyngapur-Chelyabinsk) which will move a limited amount of gas from Urengoy and the smaller neighboring fields by the decade's end. A pipeline moving associated gas to the Kuzbass region should reach full capacity by 1980. In all, the Soviets plan to install 9,500 km of large-diameter pipe⁶—much of it 1,420-mm (56-inch)—and more than 60 compressor stations, each with several turbine units. The Tyumen' trunkline system would thus become the largest single pipeline system in the world. This system will be several times greater than the proposed \$10 billion US-Canadian gas pipeline from the North Slope to western markets.

Development plans beyond 1980 are not definite. During 1981-85, however, Moscow will certainly try to bring Urengoy to its possible peak capacity of 100 billion cu m. The target date is 1982-83, and could require at least another 250 wells. The Soviet press has recently suggested the possibility of raising Urengoy's peak output to more than 200 billion cu m. No firm plans to achieve such an unprecedented production level, however, have been announced. Full development of Vyngapur, Gubkin, Komso-mol'sk, and Yubilenoy probably is also planned. Uncertain are the plans for other giant Tyumen' fields. The leading candidates for 1981-85 development would seem to be Zapolyarny and Yamburg. Although confirmatory step-out drilling⁷ is under way at both deposits, the Gas Ministry reportedly may be undecided as to whether or how extensively the two should be developed in the early 1980s. A possible debate over whether to increase Urengoy's production substantially above 100 billion cu m could be contributing to the uncertainty, as could the Gas Ministry's competition with the Oil Ministry for financial resources for the 1981-85 five-year plan period. Given a Soviet desire for continued, significant growth in gas output, however, both deposits probably will experience partial development.

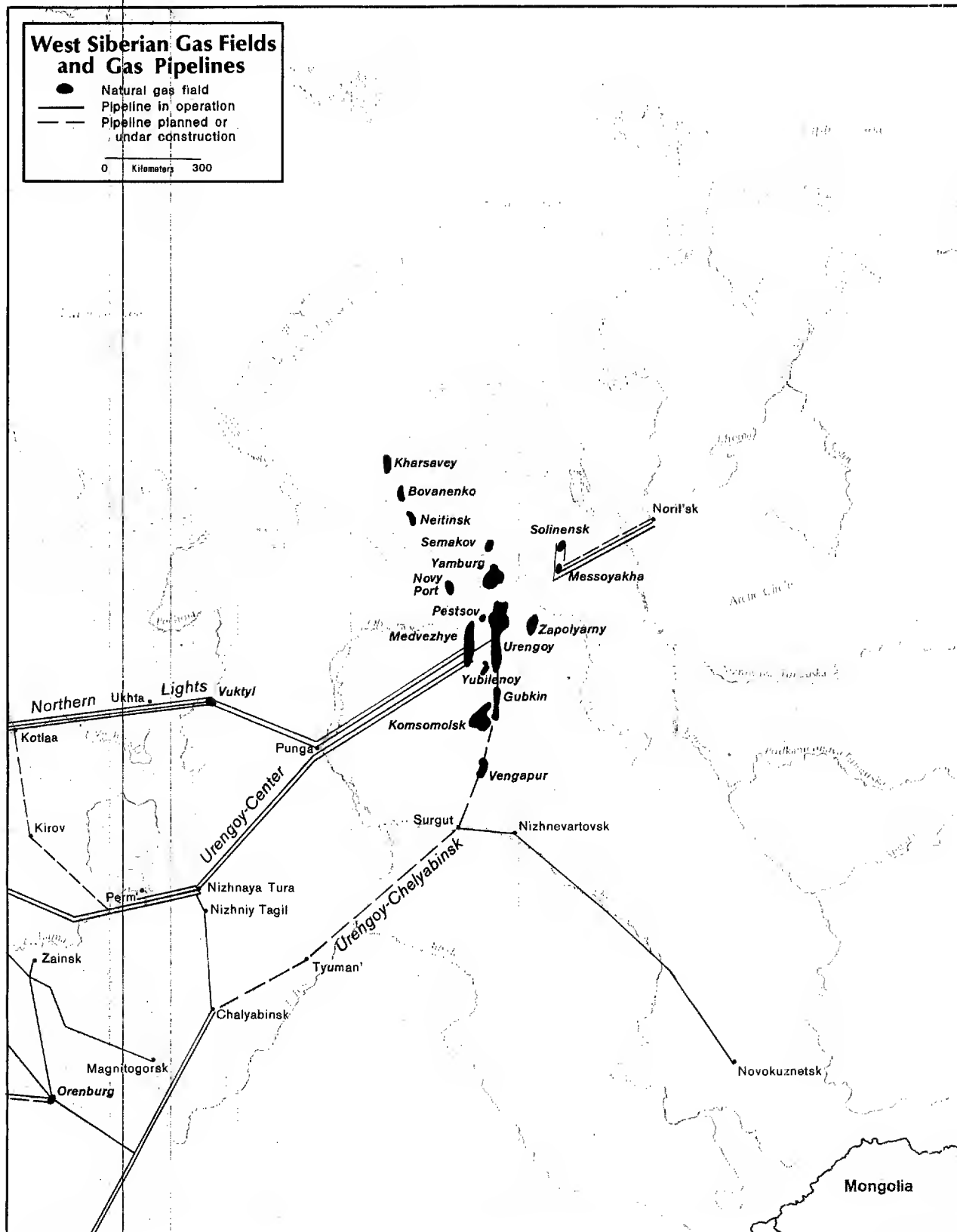
⁶ In this paper, large-diameter pipe includes diameters of 1,020 millimeters (mm) and larger. The Soviet definition often includes pipe of 530-mm diameter and larger. The largest gas pipe currently in widespread world use is 1,420-mm.

⁷ Drilling intended to gain further knowledge of a deposit's size.

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This in turn will require new trunklines connecting the new fields with existing pipeline systems—Zapolyarny linking up with the Urengoy-Chelyabinsk system and Yamburg with the Urengoy-Nadym trunkline.

Tyumen' Development Problems

West Siberia's massive gas reserves present massive exploitation problems. The location of the giant gasfields in West Siberia has posed significant difficulties for almost every phase of the gas industry's development. Although the Medvezh'ye field's development has provided valuable experience for work on other deposits, it also suggests that several problems will persist well into the 1980s.

Inadequate Infrastructure

Northern Tyumen' lacks an efficient network of all-weather roads and railways to link the region to support industries. It also requires production support facilities—such as interfield and intrafield roads, supply depots, airfields, repair facilities, communications, and power supply—all of which must be built from scratch. The same is true for housing and basic social services for the growing labor force. In Medvezh'ye's development, investment in infrastructure and wages for a large number of support personnel has cost over 1 billion rubles. Until adequate surface transport systems are built, moreover, materials supply will continue to rely heavily on air transport, which added 50 percent to Medvezh'ye's development cost.

Progress on building infrastructure has proved slow. Construction of railways and hard-surface roads has lagged substantially behind plan during the past five years and probably will do likewise during 1976-80. Tyumen' will remain unable to supply most of its own construction materials.⁸ Such support industries will continue to lag because of poor organization. Development priorities are not closely coordinated among the 20 agencies involved in West Siberian oil and gas

⁸ Northern Tyumen' plants supply only 50 percent of reinforced concrete, 15 percent of crushed rock, 25 percent of gravel, and 20 percent of wood products needed for gas industry installations.

production. As development spreads to other deposits in the early 1980s, logistics problems undoubtedly will increase.

Field Preparation

Northern Tyumen' gas deposits do not yet pose the problem of great depths that have raised drilling costs elsewhere in the USSR. Nonetheless, field development will prove difficult. Besides the delays caused by supply and infrastructure shortcomings, harsh arctic conditions interrupt drilling and construction for several months each year. The Soviets apparently are trying to reduce winter-idle-time in Urengoy's development, but the weather is probably continuing to slow operations. Thick permafrost hampers drilling and extraction; the melting and refreezing of permafrost around wells has frequently caused collapse of well casings and severe wellhead settlement, halting drilling and production. Improved casing materials, drill pipe, drilling fluid, and well refrigeration techniques are required.

Field preparation should be speeded by the Soviets' recent adoption of cluster drilling—generally the sinking of four wells from one platform. The Soviets publicly claim no significant problems. However, they have encountered severe difficulties in drilling through permafrost with their standard turbodrill and are unable to sink directional wells—a more efficient extraction method—because of the danger of melting the permafrost. These problems may persist into the 1980s, when the Soviets develop deposits further north under even thicker permafrost.

Gas processing will also challenge Soviet technology into the next decade. Drilling of large-diameter wells⁹ will enable greater exploitation of the giant fields' initially high-pressure reserves. Pressure at many fields will drop within a few years after production begins, however, necessitating additional compressor stations both at the field and along the pipeline. Condensate, hy-

⁹ Currently, this category in the Soviet gas industry includes wells of 146- to 168-mm diameters. The Soviets are also considering a large number of wells of 219- to 273-mm diameters.

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drates,¹⁰ and water seepage will become major extraction problems in a few years, requiring high-capacity processing facilities. Yet most Soviet plants are many years behind the West's, and automated processing units ensuring maximum efficiency are not likely to find widespread use. Until processing is improved, Tyumen' gaslines may occasionally suffer breaks caused partly by corrosive impurities in the gas.¹¹

Pipeline and Compressor Station Construction

The costliest, most ambitious, and most trouble-plagued sector of the Soviet gas industry is pipeline transport. As substantial gas deposits were discovered outside the Urals-Volga region, first in Central Asia and then in West Siberia, a massive network of cross-country transmission lines was built to link the remote fields with domestic and foreign consumers. During 1971-75, 31,000 km of trunklines were laid. The installation of an additional 35,400 km by 1980—mostly in West Siberia—will expand the Soviet gas trunkline network to more than 135,000 km. With the growth of West Siberian production, gas is moving over increasingly greater distances. The average distance traveled by gas in 1975 was 1,294 km compared with only 917 km in 1970. The average may rise to 1,900 km by 1980.

The Soviets have used large-diameter pipes extensively during the 1970s, becoming the first country to introduce 1,420-mm (56-inch) pipe on a major scale. Average pipeline diameter of long-distance lines increased from 815 mm in 1970 to 1,012 mm in 1975. By 1980 this figure may reach 1,082 mm. Compressor power on most lines is inadequate, holding down pipeline throughput to suboptimum levels. The Soviets must rely on imports of Western pipe and compressors to come even close to meeting their pipeline construction goals.

¹⁰ Hydrates result from the cooling of warm gas as it flows to the surface. The condensation causes water vapors to collect at the top of the well and down hole near perforations in the well casing. The water freezes, trapping the gas in hydrate form. The hydrates tend to plug the flow apertures in both areas, and at low surface temperatures may cause valves to stick or split.

¹¹ Soviet gas processing is discussed in more detail in *USSR: Development of the Gas Industry*, op. cit., appendix D.

Development Encounters Unprecedented Problems

Several methods of pipeline construction have been tried experimentally over the last dozen years with varying degrees of success: *elevated pipelines* have been known to fall off their supports, apparently because of wind-induced vibration and thermal expansion. In some cases, the supports themselves have failed because of thermal erosion of the permafrost. *Berm construction*¹² has its limitations because sand rather than gravel (which would have to be flown in) must be used for the berm. The pipeline berm is sometimes eroded by wind and water, leaving the pipe unrestrained and exposed to extreme winter temperatures, and metal failure usually results. The most successful approach has involved *ditch-buried construction*. However, heat from the gas within the pipe and thermal radiation causes the permafrost to thaw to depths of 6 meters. Pipe settlement results, producing stresses on the pipe. The Urengoy-Medvezh'ye line will be the first major trunk system crossing continuous permafrost and will probably require the use of a chilled gasline to prevent serious thermokarst damage.¹³ The USSR has no experience with chilled gasline construction and has delayed building the Urengoy-Medvezh'ye line for over a year in order to study US techniques used in the Alyeska oil pipeline and the planned arctic gas pipeline. Chilled gas pipelines, though most desirable from a construction standpoint, have large power requirements for the refrigeration equipment.

The tundra presents even larger construction problems than does the permafrost. Whereas only about 130 km of permafrost construction is planned by 1980, more than 20,000 km of swamp construction must be carried out.¹⁴ Under such

¹² A pipeline berm is an aboveground structure usually formed by a gravel pad atop which the pipe is laid. An earthen mound then covers the pipe. The gravel base provides protection against heaving action caused by repeated freezing and thawing of the ground. The earth covering insulates the pipe from destructive effects of the weather.

¹³ Thermokarst is the formation of irregular land surfaces in a permafrost region caused by a melting of ground ice. In northern Siberia the soil contains 50 to 70 percent ice by volume and thermokarst depressions up to 40 meters deep have been noted.

¹⁴ Tundra is a treeless plain characteristic of arctic and subarctic regions, usually with a marshy surface, underlain by a dark mucky soil and permafrost.

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conditions, most pipeline construction can be done only in the winter on frozen ground, the only time access roads and construction pads can be built. Depending on the method of construction, access roads can cost anywhere from 500,000 to 1 million rubles per kilometer. Swamp construction also requires numerous screw anchors and saddle weights to secure the pipeline to the mineral soil below.

Besides construction problems there are often unexplained structural failures in the pipe itself. One of the 1,420-mm lines between Nadym and Punga experiences an average of 10 breaks a year. Typically, the pipe splits open at the top over a distance of 50 to 70 meters. In other instances, ruptures 600 to 700 meters long have occurred. Some failures can apparently be traced to poor welds, laxity of inspection work, and imperfections in the pipe itself; others to inadequate pipeline maintenance and improper gas treatment processes. Failure to remove most of the sulphur and moisture content of the natural gas at the field before pipelining it can cause severe internal corrosion and a weakening of the pipe walls.

Supply of Pipe

The USSR is the world's largest producer of large-diameter steel pipe. Nonetheless, it is unable to manufacture all the large-diameter, high-quality pipe it needs for its gas and oil pipelines and depends heavily on imports from West Germany, Italy, France, and Japan. The Soviets during 1971-75 may have produced about 8 million metric tons of large-diameter welded pipe. Total Soviet demand for such pipe, however, was approximately 14 million tons, requiring imports of almost 6 million tons. During 1976-80, planned construction of 54,000 km of new oil and gas pipelines will require roughly 17 million tons of large-diameter pipe. Known Soviet purchases and orders indicate that imports in 1976-80 will reach 8 million to 10 million tons. That in turn suggests that Soviet domestic manufacture will not increase much above its 1971-75 level.

Goals for gas pipeline construction in 1981-85 may not prove as ambitious as the current five-

year plan's. The major systems linking Tyumen' gasfields and the European USSR have been started in this plan period. Moreover, the demand for additional oil trunklines will decline. However, the need to lay additional lines on all gas pipeline systems—plus the necessity of linking them with the Zapolyarny and Yamburg fields if those two deposits begin development in that period—will probably still require much more pipe than the Soviets can produce. Two new pipe mills¹⁵ are to be added to the existing five. Their combined output could increase large-diameter pipe manufacture by 2 million tons. Neither plant will reach full capacity, however, until the early 1980s. Another plant—a turnkey facility with a capacity of 250,000 to 300,000 tons—is still under negotiation with West German, French, and Japanese firms. It, too, would not begin peak operation until well after 1980. Existing plants will probably increase their output of large-diameter pipe in the next few years, but not substantially. Thus even though Soviet demand for large-diameter pipe may fall in 1981-85 by several million tons, a few million tons will probably have to be imported to cover pipe requirements for the period. Most imports would probably be made through gas-for-pipe compensation agreements, in which West European countries receive gas shipments over a fixed period of years in exchange for selling the Soviets large-diameter pipe on credit.

Compressor Shortages

The major problem presently facing the gas industry is an inability to provide the compressor capacity necessary for economical pipeline operation. Only 50 to 70 percent of the compressor stations planned for installation are actually being commissioned. The current five-year plan calls for 60 new stations per year, whereas only 40 to 45 are being built. Because of this, Soviet gas pipelines often operate at 50 percent of design capacity. The fault lies primarily with the machine building sector, which is responsible for turbine and compressor production, and with the

¹⁵ A plant to manufacture roughly 1 million tons of pipe of up to 1,220 mm is being built at Vyksa in Gor'kiy Oblast. A second plant being constructed in West Siberia will produce 1,420-mm pipe and will have a capacity of 1 million tons.

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associations responsible for installing them on the lines.¹⁶

Soviet gas pipeline compressor technology is 10 to 15 years behind that of the West. The first aircraft gas turbine compressor in the USSR was built in 1974 at the Sumy plant for heavy compressor construction. In the West, industrial use of aircraft gas turbines took place as early as 1959. The majority of Soviet gas pipeline compressor units being produced are small- to medium-capacity units of 4 to 6 megawatts (MW). The first 10-MW unit was introduced in 1972 and, by 1975, only 88 such units were in operation. Several larger compressor models—the GTK16, GTK25, GTK50, and GTK100—have been built but are only in the testing stage.

Because its own manufacturing ability is insufficient, the USSR has come to the West to obtain many of its gas pipeline compressors. In the last four years the Soviets have imported more than \$1.5 billion worth of high-capacity compressors from the West with a total power of nearly 4,000 MW. The largest purchase involved 158 compressors for the Orenburg pipeline. Contracts signed with West German and Italian firms totaled more than \$700 million. In December 1976 the USSR purchased from a UK-Canadian consortium 42 compressor units employing Avon Rolls Royce jet engines for the Urengoy-Chelyabinsk pipeline.

Of possibly greater significance than past purchases are ongoing negotiations for compressor stations using second-generation, lightweight jet engines such as the Rolls-Royce RB-211 and the GE LM-2500, developed for wide-bodied jet aircraft. Such engines offer almost double the power of first-generation engines and provide fuel savings of 15 to 20 percent (per horsepower per hour) with an increase of only 50 percent in initial cost. Current negotiations for these engines relate to a pilot project and probably involve only a few compressors. However, if the Soviet Union decided to eventually use this design on a large scale, fuel savings could be significant. Although pipeline applications of ad-

¹⁶ Most gas and oil pipelines are built by the Ministry for Construction of Oil and Gas Industry Enterprises.

vanced second-generation gas turbines such as the RB-211 are relatively new—they were first installed in Canada in 1975—such uses are likely to prove successful. In that event, this technology could assist the USSR in further developing its gas pipeline trunk network in order to meet its growing demands for piping natural gas in the 1980s.

The Role of Gas Domestically and in Foreign Trade

Domestic Consumption

The share of natural gas in the Soviet energy balance may approach or exceed that of crude oil in caloric terms by 1985.¹⁷ Gas by that time, however, will only substitute for oil domestically in some uses. Most opportunities for easy substitution of gas for oil have already been exploited. Additional gas production will go for use in industrial boilers and to industrial sectors which are already large gas consumers and in which gas is being substituted for fuels other than oil. Gas consumption will continue to increase in the chemical and metallurgical industries, where it has been replacing coal and coke. Household use will also increase but will not involve gas-for-oil substitution, because oil has not generally been used directly for heating purposes.

Significant substitution of gas for oil before 1985 probably will occur in electric power generation, where oil-burning thermal power plants can switch more readily to gas than to coal. No such shift is apparently planned for 1976-80, since the Soviets actually intend to reduce the share of gas in total thermal power plant fuel consumption during this period. Several oil-burning plants in the European USSR could make the switch in the 1980s if a domestic oil shortage required it. However, gas storage capacity near these plants would have to undergo substantial expansion to avoid winter gas supply shortages.¹⁸

¹⁷ Oil production in 1985 probably will be about 8 million to 10 million b/d. Output of natural gas probably will be 560 billion to 600 billion cu m, equivalent to about 9.4 million to 10.1 million b/d of oil.

¹⁸ Development of Soviet gas storage capacity is outlined in *USSR: Development of the Gas Industry*, op. cit., appendix E.

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Additional industrial sectors can also switch to greater gas consumption in the 1980s. Given declining Soviet oil output and a Soviet intent to minimize reliance on foreign energy sources, Moscow undoubtedly will attempt to use gas more widely through more efficient gas utilization by existing gas consumers and conversion of other industries to gas-burning power sources.

The Soviets currently show no signs of initiating the large-scale conversion campaign that would be required. The nature of significant substitution within individual industrial sectors is not clear, and further research is needed to determine the amount of gas-for-oil substitution possible for each industry within a period of five or 10 years. If the historically long Soviet lead-times characterize such an effort, a widespread shift to gas could be delayed until the late 1980s. What is unknown is the budget priorities that the Soviets would be willing to assign to a major conversion effort and the technical difficulties that they would face.

Foreign Trade

Natural gas eventually will vie with oil as the Soviets' chief foreign exchange earner. Total gas exports will increase from 26 billion cu m in 1976 to roughly 78 billion in 1985 (see table 4). Net exports—assuming moderate increases in Soviet gas imports from Iran and Afghanistan—will rise in that period from 14 billion cu m to 47 billion. In particular, rising gas exports to Western Europe—and constraints on Soviet oil production and exports—should permit gas export earnings to equal and surpass hard-currency receipts from exports of oil. Under gas trade contracts already signed—most of them exchanging gas for large-diameter pipe and ancillary equipment on credit—Soviet gas exports to Western Europe¹⁹ should rise from 12.4 billion cu m in 1976 to 25 billion cu m in 1980. By 1985, exports will probably increase to 35 billion cu m.

¹⁹ West Germany, France, Austria, and Italy. Exports also go to Finland, for which hard currency is not paid.

Table 4
USSR: Projected Trade in Natural Gas, ¹ by Country

| | Billion Cubic Meters | | | | | | |
|----------------------|----------------------|------|------|------|------|---------|------|
| | Projected | | | | | | |
| | 1976 | 1977 | 1978 | 1979 | 1980 | 1976-80 | 1985 |
| Exports | 25.8 | 32.7 | 37.3 | 45.3 | 55.5 | 196.6 | 77.8 |
| Eastern Europe | 13.4 | 16.0 | 17.5 | 24.0 | 30.6 | 101.5 | 43.1 |
| Bulgaria | 2.2 | 3.5 | 4.0 | 5.0 | 6.3 | 21.0 | 8.5 |
| Czechoslovakia | 4.3 | 4.5 | 5.0 | 5.5 | 6.3 | 25.6 | 10.0 |
| East Germany | 3.4 | 4.0 | 4.0 | 5.5 | 6.5 | 23.4 | 7.0 |
| Hungary | 1.0 | 1.0 | 1.0 | 2.5 | 4.0 | 9.5 | 5.4 |
| Poland | 2.5 | 3.0 | 3.5 | 4.5 | 6.0 | 19.5 | 8.1 |
| Romania | 0 | 0 | 0 | 1.0 | 1.5 | 2.5 | 2.1 |
| Yugoslavia | 0 | 0 | 0 | 0 | 0 | 0 | 2.0 |
| Western Europe | 12.4 | 16.7 | 19.8 | 21.3 | 24.9 | 95.1 | 34.7 |
| Austria | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 14.0 | 4.0 |
| Finland | 0.9 | 0.9 | 1.0 | 1.0 | 1.4 | 5.2 | 1.0 |
| France | 1.0 | 1.5 | 2.0 | 2.0 | 4.7 | 11.2 | 7.7 |
| Italy | 3.7 | 6.5 | 7.0 | 7.0 | 7.0 | 31.2 | 7.0 |
| West Germany | 4.0 | 5.0 | 7.0 | 8.5 | 9.0 | 33.5 | 15.0 |
| Imports | 11.8 | 12.9 | 12.9 | 13.0 | 14.6 | 65.2 | 31.0 |
| Afghanistan | 2.5 | 2.9 | 2.9 | 3.0 | 4.0 | 15.3 | 4.0 |
| Iran | 9.3 | 10.0 | 10.0 | 10.0 | 10.6 | 49.9 | 27.0 |
| Net Trade | 14.0 | 19.8 | 24.4 | 32.3 | 40.9 | 131.4 | 46.8 |

¹ Actual for 1976. Source: *Vneshnyaya torgovlya SSSR 1976*, Moscow (1977). Trade estimates for the years 1977-80 and 1985 are based on (a) known Soviet - West Europe trade agreements; (b) for Eastern Europe, the trade arrangement under Orenburg pipeline agreement and assumed annual increments in gas deliveries to certain CEMA customers; (c) scheduled increases in imports from Iran under the "trilateral switch" deal and assumed slight increases in imports from Afghanistan.

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Much of the 1981-85 jump will involve exports of Iranian gas to West Germany, France, and Austria via the Soviet Union.²⁰ The Soviet share of Western Europe's total gas supply by 1985 will probably not exceed 12 percent.

Even if growth in gas production slows toward the mid-1980s, the Soviets are likely to honor existing hard-currency contracts. Although they may not always fulfill annual commitments—

they will strive to supply ultimately all the gas called for over the contract period. Foreign currency earnings from gas of \$1 billion in 1980 (in 1977 prices) will surpass neither the \$4.5 billion obtained in 1976 from exports of oil nor the potential earnings of \$2.7 billion from oil exports in 1980. By 1985, however, gas will have emerged as the leading foreign exchange earner, with gross hard currency receipts of \$2 billion (in 1977 prices), while the Soviets may have become net importers of oil. LNG exports could also provide substantial revenues for Soviet gas. The proposed LNG project most likely to produce exports is a joint Soviet-US-Japanese venture to bring East Siberian gas from the Vilyuy field to the Soviet Pacific coast for liquefaction. No LNG exports, however, are likely before the very late 1980s at the earliest, and will only be forthcoming if a sufficiently large market develops in the United States and Japan. Meanwhile the importance of gas to Soviet trade will prove substantial. At the very least, gas will provide an increasing portion of the purchasing power needed to cover the rising costs of Soviet imports of Western technology and equipment that expansion of gas production in the 1980s will require.

Gas exports to Eastern Europe through 1985 will remain larger than those to the West, constituting roughly 55 percent of total gas exports in

²⁰ Signed in 1975, the "trilateral switch" deal will entail the transmitting of gas from Iran's Kangan field to the increasingly gas-poor Soviet Caucasus. The Soviets in turn will export gas from their own Siberian and Urals fields to Western Europe. The Soviets will import 17 billion cu m annually from Iran and reexport 15 billion, keeping 2 billion cu m as a "transit fee." Czechoslovakia will receive 3.6 billion cu m of the reexported gas, the West European consortium taking 11.4 billion. The agreement is to go into effect in stages, beginning in 1981, although it probably will begin later.

that period. By 1980 the USSR should be supplying almost 100 percent of Eastern Europe's gas imports. Soviet shipments to CEMA members²¹ will rise from 13 billion cu m in 1976 to 31 billion in 1980 and to about 41 billion cu m in 1985. Much of the increase through the early 1980s will come from gas transmitted via the Orenburg pipeline,²² which should begin sending some gas in early 1979. How much the Soviets will actually export to Eastern Europe by the mid-1980s is uncertain. With CEMA still heavily dependent on Soviet energy supplies, Moscow may significantly increase gas shipments if Soviet ability to export oil declines. The Soviets have recently indicated that such an action is a distinct possibility. In that case, the Soviets may avoid agreements with Western Europe for hard currency gas deliveries additional to those already contracted for. Moscow would hesitate to do this because its ability to import large-diameter pipe via gas-for-pipe compensation deals would be reduced. Soviet flexibility in raising gas exports beyond 1980 to both Eastern and Western Europe will thus depend on how rapidly output is increased.

Prospects

Soviet natural gas production will increase substantially through 1985. The 1980 plan goal of 435 billion cu m is not likely to be met, but 1985 output should reach 560 billion to 600 billion cu m, an annual growth rate during 1981-85 of roughly 6.0 to 7.5 percent (see table 5). However, if certain difficulties facing the gas industry are not reduced within the next few years, not even West Siberia's large gas reserves

²¹ The Council for Mutual Economic Assistance. Members receiving Soviet gas are Bulgaria, East Germany, Czechoslovakia, Hungary, Poland, and Romania. Yugoslavia, not a CEMA member, may begin receiving gas shipments after 1980.

²² The Orenburg pipeline is a joint CEMA project for construction of a 2,750-km trunkline from the Orenburg field, in the Urals, to the Czechoslovak border. Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania were to contribute men or capital to the project, in return for 2.8 billion cu m annually to each (1.5 billion cu m to Romania). Most CEMA members have fallen behind on their commitments of men, and Soviet crews have wound up building most of the line. Although the line itself may be completed slightly beyond the late-1978 deadline, a slow buildup of compressor capacity on the line could delay full deliveries of gas to the CEMA recipients.

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Table 5
Projected ¹ Gas Production

| | Billion Cubic Meters | Average Annual Percent Growth |
|---------------|----------------------|-------------------------------|
| 1975..... | 289 | |
| 1980..... | 415-420 | 7.5-7.8 ² |
| 1985..... | 560-600 | 5.9-7.7 ² |
| 1976-85 | | 6.8-7.6 ³ |

¹ CIA projections.² Five-year period.³ Ten-year period.

will be able to guarantee constant production growth beyond 1985. The Soviets themselves, with unusual frankness, recently suggested that gas output might even level off "sometime" in the 1980s.²³ Two basic problems underlie that concern: (a) rapidly falling production at older gasfields and (b) persistent bottlenecks—particularly pipeline construction and operation—hindering expansion of Siberian gas output.

Production Losses

Gas production at older fields in the European USSR and in Central Asia may be falling much more quickly than anticipated. Moscow has planned for a certain loss in output from these fields during 1976-80 while investing heavily since 1970 to minimize that loss. North Caucasus gas production began its decline in the 1960s; the more important producing regions of the Uzbek SSR and the Ukraine began a slow downturn in the early 1970s. The intensive and sometimes wasteful exploitation methods practiced to achieve rapid growth in the late 1960s may have led to a dramatic fall-off in capacity at most major Ukrainian and Uzbek fields. The giant deposits of Shebelinka (Ukraine) and Gazli

(Uzbek) are falling sharply, and no significant deposits have been found to replace them.²⁴ An unprecedented Soviet failure during 1977 to report regional gas production figures—combined with recent Soviet statements—suggests that output in the Ukraine and Uzbek is falling faster than planned. A precise projection of the amount of output loss is difficult. An aggregate Ukrainian gas production plan for 1976-80, however, indirectly indicated that output there could drop to roughly 50 billion cu m by 1980 rather than the 59 billion cu m earlier planned.²⁵

Siberian Bottlenecks

Lagging pipeline and compressor station construction probably will prevent Tyumen' gas production from fulfilling its 1980 plan of 155 billion cu m. That problem, plus difficulties in developing giant gasfields located above the Arctic Circle, will also limit growth during the 1980s. Inadequate compressor capacity on the three trunklines scheduled to move gas from northern Tyumen' to the European USSR will prove a major constraint on growth through 1980. Medvezh'ye, Urengoy, and smaller neighboring fields probably will reach their planned aggregate capacity of 139 billion cu m by 1980.²⁶ Moreover, the three pipeline systems—Urengoy-Center, Northern Lights, and perhaps the first two lines of Urengoy-Chelyabinsk—are likely to have been laid by that time. However, Soviet delays in negotiating imports of Western tur-

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²⁵ A 1976-80 aggregate production goal for the Ukraine of 265 billion cu m (*Neftyanaya i gazovaya promyshlennost'* no.1 (January-March 1977), p. 2) suggested an annual average output of 53 billion cu m for the period. Since Ukrainian production in 1976, 1977, and perhaps 1978 and 1979 will be higher than that, 1980 output should be considerably lower than 53 billion.

²⁶ The remainder of the 155 billion cu m planned for Tyumen' Oblast will come primarily from associated gas production at the region's major oilfields. That output will move southward via the Nizhnevartovsk-Kuzbass line, to be completed in late 1978 or early 1979, which should reach full capacity by 1980.

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bines and compressors, long leadtimes for those units' manufacture and delivery, and slow Soviet installation of the units will allow perhaps only 120 billion to 125 billion cu m to be moved—15 billion to 20 billion cu m below plan. Serious pipeline failures, such as pipe settlement into permafrost and pipe ruptures, could also easily prevent Tyumen' fields from meeting their goals. The Soviets themselves have indicated concern with these problems by having long retained the range of 400 billion to 435 billion cu m in the 1980 plan, only recently setting a firm goal of 435 billion cu m.

Reliance on the West

Soviet gas production will remain dependent on imports of Western equipment well into the next decade. Both large-diameter pipe and compressors will continue to be produced in insufficient quantity and quality to meet the gas industry's needs. The Soviets will attempt to increase their manufacture of those two vital inputs, as well as of other pipeline and field-related equipment. However, the necessity of developing new and even more remote Siberian deposits will overtax Soviet industrial and construction capacity, particularly since the oil industry will also claim many of those same resources. Should Moscow try to mount a crash campaign to develop several giant gas deposits simultaneously, reliance on Western equipment will further increase.

Besides pipe and compressors, the Soviets can use assistance in several areas. Gas Ministry officials have admitted weaknesses in many phases of drilling in permafrost, including prevention of melting permafrost, cementing of wells, use of special packer fluid and drilling fluid, use of improved drill pipe and bits, and overall well design. They have also had problems in determining the optimal spacing of production wells, drilling pads, and related support bases and in deciding the optimal arrangement of gathering lines and gas processing installations—particularly facilities to cool gas before transmission by trunkline. Most Soviet gas-processing plants and pipeline testing techniques are years behind the West. Leakages in production well

tubing is emerging as a widespread problem, and the Ministry is looking to the West for improved tubing products. Many of the above problems may require Western technical assistance as well as equipment imports.

The ability of Western assistance to significantly increase growth of Tyumen' gas production is severely constrained. Although the West's capacity to supply pipe, turbines, and other equipment should pose no problem, Moscow's hard currency reserves may prove inadequate to purchase all needed items. Pipe and related imports for 1976-80 have apparently been obtained with few difficulties. As Soviet oil exports—and oil foreign exchange earnings—decline in the early 1980s, however, natural gas exports will probably not cover the entire revenue loss. Consequently more of the hard currency earnings of gas may go toward other types of imports. If the oil industry maintains substantial equipment imports, foreign exchange available for gas-related purchases will be further limited. In this situation, a shortage of large-diameter pipe could become the most critical bottleneck facing the gas industry's expansion. Moreover, what equipment or direct Western involvement Moscow is able and willing to purchase may not solve all the problems of Tyumen' development. Western technology may prove not much more successful at rapidly overcoming permafrost difficulties than the Soviets, who have had considerably longer experience in that field. More likely, Western assistance will not remove the major bottlenecks created by Soviet organizational and industrial shortcomings. If basic infrastructure—particularly pipeline capacity—in northern Tyumen' remains woefully inadequate, Soviet investment in Western technical expertise will not produce satisfactory returns.

Rising Costs

Costs of Soviet gas production since the early 1970s have risen faster than those for any other major energy sector (see table 6). Although gas will remain less expensive to produce than oil or coal, its costs will continue to rise significantly. Investment in further drilling in the older gas-fields of the Ukraine, northern Caucasus, and

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Table 6

Change in Production Costs in Constant Prices ¹

| Industry | Percent | |
|-----------------------------------|-------------------|-------------------|
| | 1970 Over 1965 | 1975 Over 1970 |
| Oil extraction | -3.0 | 12.6 |
| Gas production ² | 8.5 | 45.9 |
| Coal production | 5.6 | 6.8 |
| Electric power | 0.1 | 2.4 |

¹ CIA estimates.² Does not include pipeline transport or storage.

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Central Asia will constitute a progressively smaller share of total gas industry outlays, but as those regions' output falls more sharply beyond 1980, returns on that investment will plummet. Delays in bringing Tyumen' Oblast's gasfields and pipelines to full capacity, however, will prove the major source of higher costs. Development of the Urengoy, Yamburg, and Zapolyarny fields will require unprecedented outlays for infrastructure and for production and pipeline equipment, hiking total gas industry investment in 1981-85 well beyond the 19 billion rubles initially allocated for 1976-80. However, the Soviets' likely failure to construct an adequate infrastructure before 1985 will drag out field development while maintaining high costs for transport of supplies. Buildup of pipeline capacity will probably remain behind schedule, preventing existing production capacity from being fully used and thus lowering investment returns.

Stepped-Up Campaign

Moscow's concern over the pace of Tyumen' gas development appears to have grown in recent

months. Correspondingly, the Soviets have shown signs of stepping up their campaign to open the region's giant gas deposits. Since mid-1977, Soviet press articles criticizing slow or sloppy handling of pipeline and field construction projects have increased in number and frankness. Major stories in *Pravda*, *Izvestia*, *Sotsialisticheskaya industriya*, and *Trud* have aired complaints regarding those problems as well as the basic lack of infrastructure needed for industry support.

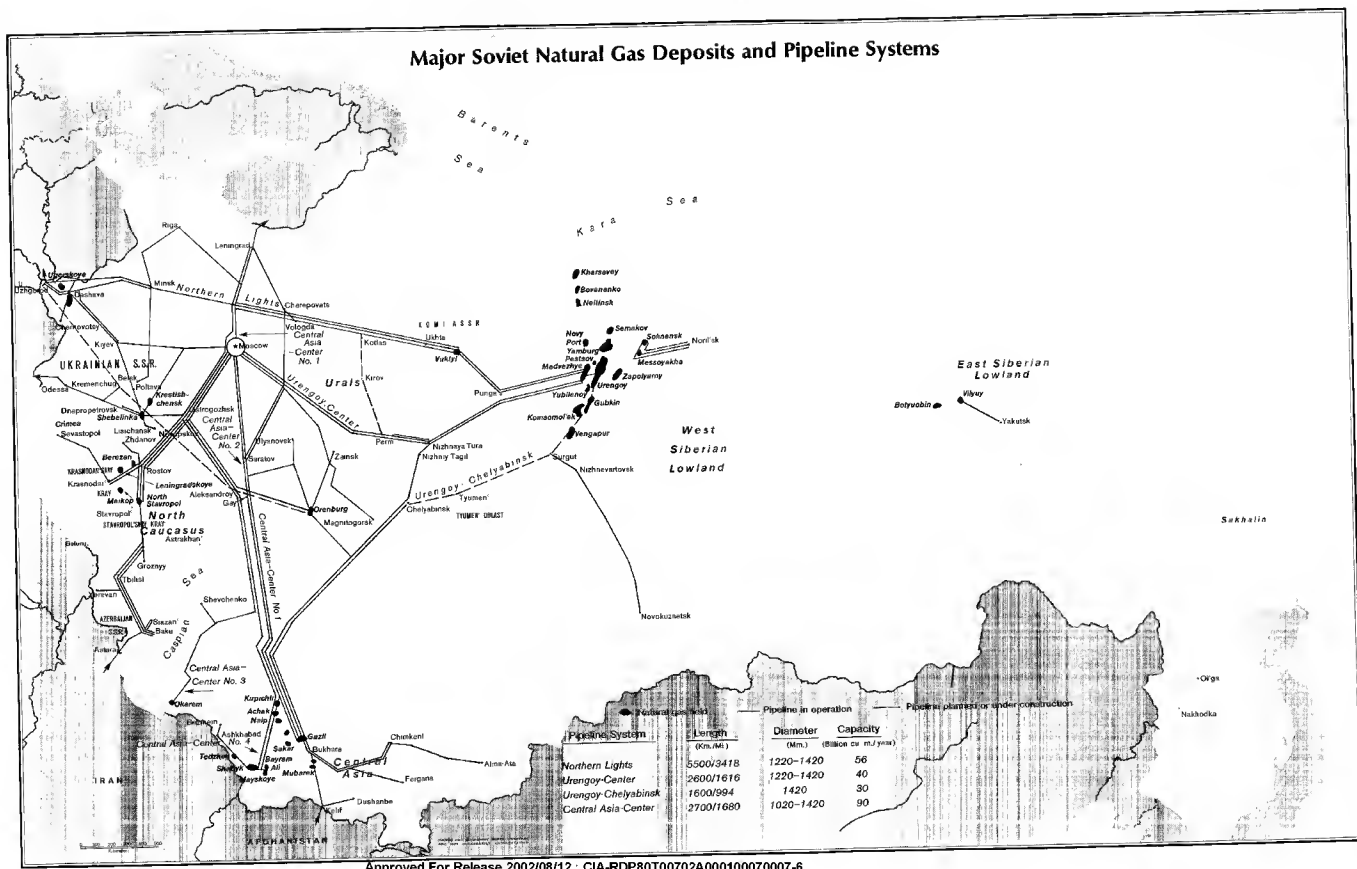
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As a result, budgetary allocations to the gas industry reportedly have been increased—along with those for oil—beyond the 19 billion rubles originally provided to the Gas Ministry for 1976-80. In effect, Moscow appears to be shifting resources from older gas-producing areas to West Siberia, where it calculates that returns on investment will prove higher. Additional men and equipment have already been transferred to Tyumen' oil and gas regions. However, the lack of infrastructure, particularly in areas surrounding large gas deposits as yet undeveloped, plus the persistent problem of building up pipeline capacity will probably prevent these extra resources from producing much more gas over the next several years than would be produced without them. Moreover, transfer of resources from older gasfields, especially those in the Ukraine, will ultimately force output there to drop even faster, undercutting part of the additional increment in Tyumen' output that the stepped-up campaign will induce.

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